SMatrix

An active library for high performance computations in C++

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Contents

1 SMatrix — *An active library for high performance vector and matrix computations in C++* 3
1.1 SVector — *SVector* 6
1.2 SMatrix — *SMatrix* 9
1.3 Expr — *Expr.* 14
1.4 BinaryOp — *BinaryOp* 15
1.5 UnaryOp — *UnaryOp* 15
1.6 Constant — *Constant* 16
1.22 Invert — *Invert* 21
1.23 0 — *Invert<0>* 22
1.24 1 — *Invert<1>* 22
1.25 2 — *Invert<2>* 23
1.26 3 — *Invert<3>* 23

2 SVertex — *A high-speed C++ vertex fit class (formerly Vt++).* 28
2.1 SVertex — *Fixed size Vertex class* 28
2.1.1 — TrackIf Access methods — 34
2.2 SKalman — *Fixed size Kalman filter class* 35

3 SDistance — *Distance functions for Track and Vertex objects.* 39

Class Graph 45

1

SMatrix

An active library for high performance vector and matrix computations in C++

Names

1.1 template <class T, unsigned int D> class
SVector *SVector* 6

1.2 template <class T, unsigned int D1, unsigned int D2 = D1> class
SMatrix *SMatrix* 9

1.3 template <class ExprType, class T, unsigned int D, unsigned int D2 = 0> class
Expr *Expr.* 14

1.4 template <class Operator, class LHS, class RHS, class T> class
BinaryOp *BinaryOp* 15

1.5 template <class Operator, class RHS, class T> class
UnaryOp *UnaryOp* 15

1.6 template <class T> class
Constant *Constant* 16

1.7 template <class T> inline const T
square (const T& x)
square 16

1.8 template <class T> inline const T
maximum (const T& lhs, const T& rhs)
maximum 17

1.9 template <class T> inline const T
minimum (const T& lhs, const T& rhs)
minimum 17

1.10 template <class T> inline int
round (const T& x)
round 17

1.11 template <class T> inline const int
sign (const T& x) *sign* 18

1.12 template <class T, unsigned int D> inline T
dot (const SVector<T, D>& lhs,
const SVector<T, D>& rhs)
dot 18

1.13 template <class T, unsigned int D> inline T

mag2 (const SVector<T, D>& rhs)
mag2 18

1.14 template <class T, unsigned int D> inline T
mag (const SVector<T, D>& rhs)
mag 19

1.15 template <class T> inline T
Lmag2 (const SVector<T, 4>& rhs)
Lmag2 19

1.16 template <class T> inline T
Lmag (const SVector<T, 4>& rhs)
Lmag 19

1.17 template <class T> inline SVector <T, 3>
cross (const SVector<T, 3>& lhs,
const SVector<T, 3>& rhs)
cross 20

1.18 template <class T, unsigned int D> inline SVector <T, D>
unit (const SVector<T, D>& rhs)
unit 20

1.19 template <class Matrix, unsigned int n, unsigned int idim> bool
Dfact (Matrix& rhs,
typename Matrix::value_type& det)
Dfact 20

1.20 template <class Matrix, unsigned int n, unsigned int idim> bool
Dfactir (Matrix& rhs,
typename Matrix::value_type& det,
unsigned int* ir)
Dfactir 21

1.21 template <class Matrix, unsigned int n, unsigned int idim> bool
Dfinv (Matrix& rhs, unsigned int* ir)
Dfinv 21

1.22 template <unsigned int idim, unsigned int n = idim> class
Invert *Invert* 21

1.23 template <> class Invert
0 *Invert<0>* 22

1.24 template <> class Invert
1 *Invert<1>* 22

1.25 template <> class Invert
2 *Invert<2>* 23

1.26 template <> class Invert

3 *Invert<3>* 23

1.27 template <class Matrix, unsigned int n, unsigned int idim> bool
Dsfact (Matrix& rhs,
typename Matrix::value_type& det)
Dsfact 24

1.28 template <class T, int n, int idim> bool
Dsinv (T* a) *Dsinv* 24

1.29 template <class T> T
erf_0_ (int n, const T& rhs)
*erf_0_* 24

1.30 template <class T> T
erf (const T& rhs)
Error function 25

1.31 template <class T> T
erfc (const T& rhs)
Error function 25

1.32 template <class T> T
Prob (const T& rhs, int n)
Upper Tail Probability of Chi-Squared Distribution 25

1.33 static bool
errfunc (const char* expr,
const char* function,
const unsigned int line)
errfunc 26

1.34 #define **Sassert** (expr) *Sassert* 26

1.35 template <class T, class P> bool
Rminfc (T (*f)(P), P a, P b, double eps,
double delta, P& x, P& y)
Rminfc 26

1.36 template <class C, class T, class P> bool
RminfcM (const C& part, T (C::*f)(P) const,
P a, P b, double eps, double delta,
P& x, P& y)
RminfcM 27

Author: T. Glebe, MPI fuer Kernphysik Heidelberg

1.1

template <class T, unsigned int D> class **SVector**

SVector

Public Members

— Typedefs —

typedef T **value_type**

— Constructors —

SVector ()

template <class A>
SVector (const Expr<A, T, D>& rhs)

SVector (const SVector<T, D>& rhs)

template <unsigned int D1>
SVector (const SVector<T, D1>& rhs)
$D1 \leq D$ required!

template <unsigned int D1>
SVector (const T& a1, const SVector<T, D1>& rhs)
$D1 \leq D - 1$ required!

SVector (const T* a, unsigned int len)
fill from array, len must be equal to D!

SVector (const T& rhs)

SVector (const T& a1, const T& a2)

SVector (const T& a1, const T& a2, const T& a3)

SVector (const T& a1, const T& a2, const T& a3, const T& a4)

SVector (const T& a1, const T& a2, const T& a3, const T& a4, const T& a5)

SVector (const T& a1, const T& a2, const T& a3, const T& a4, const T& a5, const T& a6)

SVector (const T& a1, const T& a2,
const T& a3, const T& a4,
const T& a5, const T& a6,
const T& a7)

SVector (const T& a1, const T& a2,
const T& a3, const T& a4,
const T& a5, const T& a6,
const T& a7, const T& a8)

SVector (const T& a1, const T& a2,
const T& a3, const T& a4,
const T& a5, const T& a6,
const T& a7, const T& a8,
const T& a9)

SVector (const T& a1, const T& a2,
const T& a3, const T& a4,
const T& a5, const T& a6,
const T& a7, const T& a8,
const T& a9, const T& a10)

SVector <T, D> &
operator= (const T& rhs)

template <class A> SVector <T, D> &
operator= (const Expr<A, T, D>& rhs)

— Access functions —

inline static unsigned int
dim () *return dimension D*

T **apply** (unsigned int i) const
access the parse tree

const T* **Array** () const *return read-only pointer to internal array*

T* **Array** () *return pointer to internal array*

— Operators —

bool **operator==** (const T& rhs) const
element wise comparison

bool **operator!=** (const T& rhs) const

element wise comparison

bool **operator==** (const SVector<T, D>& rhs) const
element wise comparison

bool **operator!=** (const SVector<T, D>& rhs) const
element wise comparison

template <class A> bool
operator== (const Expr<A, T, D>& rhs) const
element wise comparison

template <class A> bool
operator!= (const Expr<A, T, D>& rhs) const
element wise comparison

bool **operator**> (const T& rhs) const
element wise comparison

bool **operator**< (const T& rhs) const
element wise comparison

bool **operator**> (const SVector<T, D>& rhs) const
element wise comparison

bool **operator**< (const SVector<T, D>& rhs) const
element wise comparison

template <class A> bool
operator> (const Expr<A, T, D>& rhs) const
element wise comparison

template <class A> bool
operator< (const Expr<A, T, D>& rhs) const
element wise comparison

const T& **operator[]** (unsigned int i) const
read-only access

const T& **operator()** (unsigned int i) const
read-only access

T& **operator[]** (unsigned int i)
read/write access

T& **operator()** (unsigned int i)
read/write access

SVector <T, D> &
operator+= (const SVector<T, D>& rhs)

template <class A> SVector <T, D> &
operator+= (const Expr<A, T, D>& rhs)

SVector <T, D> &

operator-= (const SVector<T, D>& rhs)

template <class A> SVector <T, D> &
operator-= (const Expr<A, T, D>& rhs)

SVector <T, D> &
operator*= (const SVector<T, D>& rhs)

template <class A> SVector <T, D> &
operator*= (const Expr<A, T, D>& rhs)

SVector <T, D> &
operator/= (const SVector<T, D>& rhs)

template <class A> SVector <T, D> &
operator/= (const Expr<A, T, D>& rhs)

— Expert functions —

SVector <T, D> &
unit () *transform vector into a vector of lenght 1*

template <unsigned int D2> SVector <T, D> &
place_at (const SVector<T, D2>& rhs, const unsigned int row)
place a sub-vector starting at <row>

template <class A, unsigned int D2> SVector <T, D> &
place_at (const Expr<A, T, D2>& rhs, const unsigned int row)
place a sub-vector starting at <row>

std::ostream&
print (std::ostream& os) const
used by operator<<()

SVector. A generic fixed size Vector class.

Author: T. Glebe

1.2

template <class T, unsigned int D1, unsigned int D2 = D1> class **SMatrix**

SMatrix

Public Members

— Typedefs —

typedef T **value_type**

— Constructors —

SMatrix ()

SMatrix (const SMatrix<T, D1, D2>& rhs)

template <class A>
SMatrix (const Expr<A, T, D1, D2>& rhs)

SMatrix (const T& rhs,
const bool diagonal=false)
2nd arg: set only diagonal?

SMatrix (const SVector<T, D1>& rhs)
constructor via dyadic product

template <class A>
SMatrix (const Expr<A, T, D1>& rhs)
constructor via dyadic product

template <class T1>
SMatrix (const T1* a, const bool triang=false,
const unsigned int len=D1*D2)
constructor via array, triag=true: array contains only upper/lower triangular part of a symmetric matrix, len: length of array

SMatrix <T, D1, D2> &
operator= (const T& rhs)

template <class A> SMatrix <T, D1, D2> &
operator= (const Expr<A, T, D1, D2>& rhs)

static const unsigned int
rows *return no. of matrix rows*

static const unsigned int
cols *return no. of matrix columns*

static const unsigned int
size *return no of elements: rows*columns*

— Access functions —

T **apply** (unsigned int i) const

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Malte Zöckler

access the parse tree

const T* **Array** () const — *return read-only pointer to internal array*

T* **Array** () — *return pointer to internal array*

— Operators —

bool **operator==** (const T& rhs) const
element wise comparison

bool **operator!=** (const T& rhs) const
element wise comparison

bool **operator==** (const SMatrix<T, D1, D2>& rhs) const
element wise comparison

bool **operator!=** (const SMatrix<T, D1, D2>& rhs) const
element wise comparison

template <class A> bool
operator== (const Expr<A, T, D1, D2>& rhs) const
element wise comparison

template <class A> bool
operator!= (const Expr<A, T, D1, D2>& rhs) const
element wise comparison

bool **operator**> (const T& rhs) const
element wise comparison

bool **operator**< (const T& rhs) const
element wise comparison

bool **operator**> (const SMatrix<T, D1, D2>& rhs) const
element wise comparison

bool **operator**< (const SMatrix<T, D1, D2>& rhs) const
element wise comparison

template <class A> bool
operator> (const Expr<A, T, D1, D2>& rhs) const
element wise comparison

template <class A> bool

operator< (const Expr<A, T, D1, D2>& rhs) const
element wise comparison

const T& **operator()** (unsigned int i, unsigned int j) const
read-only access

T& **operator()** (unsigned int i, unsigned int j)
read/write access

SMatrix <T, D1, D2> &
operator+= (const SMatrix<T, D1, D2>& rhs)

template <class A> SMatrix <T, D1, D2> &
operator+= (const Expr<A, T, D1, D2>& rhs)

SMatrix <T, D1, D2> &
operator-= (const SMatrix<T, D1, D2>& rhs)

template <class A> SMatrix <T, D1, D2> &
operator-= (const Expr<A, T, D1, D2>& rhs)

SMatrix <T, D1, D2> &
operator*= (const SMatrix<T, D1, D2>& rhs)

template <class A> SMatrix <T, D1, D2> &
operator*= (const Expr<A, T, D1, D2>& rhs)

SMatrix <T, D1, D2> &
operator/= (const SMatrix<T, D1, D2>& rhs)

template <class A> SMatrix <T, D1, D2> &
operator/= (const Expr<A, T, D1, D2>& rhs)

— Expert functions —

bool **sinvert** () *invert symmetric, pos. def. Matrix via Dsinv*

1.2.1 bool **sdet** (T& det) *determinant of symmetrc, pos*

14

bool **invert** () *invert square Matrix via Dinv*

1.2.2 bool **det** (T& det) *determinant of square Matrix via Dfact* 14

template <unsigned int D> SMatrix <T, D1, D2> &
place_in_row (const SVector<T, D>& rhs, const unsigned int row, const unsigned int col)
place a vector in a Matrix row

template <class A, unsigned int D> SMatrix <T, D1, D2> &

place_in_row (const Expr<A, T, D>& rhs,
const unsigned int row,
const unsigned int col)
place a vector expression in a Matrix row

template <unsigned int D> SMatrix <T, D1, D2> &
place_in_col (const SVector<T, D>& rhs,
const unsigned int row,
const unsigned int col)
place a vector in a Matrix column

template <class A, unsigned int D> SMatrix <T, D1, D2> &
place_in_col (const Expr<A, T, D>& rhs,
const unsigned int row,
const unsigned int col)
place a vector expression in a Matrix column

template <unsigned int D3, unsigned int D4> SMatrix <T, D1, D2> &
place_at (const SMatrix<T, D3, D4>& rhs,
const unsigned int row,
const unsigned int col)
place a matrix in this matrix

template <class A, unsigned int D3, unsigned int D4> SMatrix <T, D1, D2> &
place_at (const Expr<A, T, D3, D4>& rhs,
const unsigned int row,
const unsigned int col)
place a matrix expression in this matrix

SVector <T, D2>
row (const unsigned int therow) const
return a Matrix row as a vector

SVector <T, D1>
col (const unsigned int thecol) const
return a Matrix column as a vector

std::ostream&
print (std::ostream& os) const
used by operator<<()

SMatrix. A generic fixed size n x m Matrix class.q

Author: T. Glebe

1.2.1

bool **sdet** (T& det)

determinant of symmetrc, pos

determinant of symmetrc, pos. def. Matrix via Dsfact. **Note:** this will destroy the contents of the Matrix!

1.2.2

bool **det** (T& det)

determinant of square Matrix via Dfact

determinant of square Matrix via Dfact. **Note:** this will destroy the contents of the Matrix!

1.3

template <class ExprType, class T, unsigned int D, unsigned int D2 = 0> class **Expr**

Expr.

Public Members

Expr (const ExprType& rhs)

~**Expr** ()

inline T **apply** (unsigned int i) const

static const unsigned int

rows

static const unsigned int
cols

std::ostream&
print (std::ostream& os) const
used by operator<<()

Expr. An Expression wrapper class.

Author: T. Glebe

1.4

template <class Operator, class LHS, class RHS, class T> class **BinaryOp**

BinaryOp

Public Members

BinaryOp (Operator op, const LHS& lhs, const RHS& rhs)

~**BinaryOp** ()

inline T **apply** (unsigned int i) const

BinaryOp. A class representing binary operators in the parse tree.

Author: T. Glebe

1.5

template <class Operator, class RHS, class T> class **UnaryOp**

UnaryOp

Public Members

UnaryOp (Operator op, const RHS& rhs)

~**UnaryOp** ()

inline T **apply** (unsigned int i) const

UnaryOp. A class representing unary operators in the parse tree.

Author: T. Glebe

1.6

template <class T> class **Constant**

Constant

Public Members

Constant (const T& rhs)

~**Constant** ()

inline T **apply** (unsigned int i) const

Constant. A class representing constant expressions (literals) in the parse tree.

Author: T. Glebe

1.7

template <class T> inline const T **square** (const T& x)

square

square. Template to compute $x \cdot x$

Author: T. Glebe

1.8

template <class T> inline const T **maximum** (const T& lhs, const T& rhs)

maximum

maximum. Template to compute $\max(i, j)$

Author: T. Glebe

1.9

template <class T> inline const T **minimum** (const T& lhs, const T& rhs)

minimum

minimum. Template to compute $\min(i, j)$

Author: T. Glebe

1.10

template <class T> inline int **round** (const T& x)

round

round. Template to compute nearest integer value.

Author: T. Glebe

1.11

template <class T> inline const int **sign** (const T& x)

sign

sign. Template to compute the sign of a number sgn(i).

Author: T. Glebe

1.12

template <class T, unsigned int D> inline T **dot** (const SVector<T, D>& lhs, const SVector<T, D>& rhs)

dot

dot. Template to compute $\vec{a} \cdot \vec{b} = \sum_i a_i \cdot b_i$.

Author: T. Glebe

1.13

template <class T, unsigned int D> inline T **mag2** (const SVector<T, D>& rhs)

mag2

mag2. Template to compute $|\vec{v}|^2 = \sum_i v_i^2$.

Author: T. Glebe

1.14

template <class T, unsigned int D> inline T **mag** (const SVector<T, D>& rhs)

mag

mag. Length of a vector: $|\vec{v}| = \sqrt{\sum_i v_i^2}$.

Author: T. Glebe

1.15

template <class T> inline T **Lmag2** (const SVector<T, 4>& rhs)

Lmag2

Lmag2. Template to compute $|\vec{v}|^2 = v_0^2 - v_1^2 - v_2^2 - v_3^2$.

Author: T. Glebe

1.16

template <class T> inline T **Lmag** (const SVector<T, 4>& rhs)

Lmag

Lmag. Length of a vector Lorentz-Vector: $|\vec{v}| = \sqrt{v_0^2 - v_1^2 - v_2^2 - v_3^2}$.

Author: T. Glebe

1.17

template <class T> inline SVector <T,3> **cross** (const SVector<T, 3>& lhs, const SVector<T, 3>& rhs)

cross

cross. Cross product of two 3-dim vectors: $\vec{c} = \vec{a} \times \vec{b}$.

Author: T. Glebe

1.18

template <class T, unsigned int D> inline SVector <T,D> **unit** (const SVector<T, D>& rhs)

unit

unit. Return a vector of unit lenght: $\vec{e}_v = \vec{v}/|\vec{v}|$.

Author: T. Glebe

1.19

template <class Matrix, unsigned int n, unsigned int idim> bool **Dfact** (Matrix& rhs, typename Matrix::value_type& det)

Dfact

Dfact. Function to compute the determinant from a square matrix ($\det(A)$) of dimension $idim$ and order n.

Author: T. Glebe

1.20

template <class Matrix, unsigned int n, unsigned int idim> bool **Dfactir** (Matrix& rhs, typename Matrix::value_type& det, unsigned int* ir)

Dfactir

Dfactir. Function to compute the determinant from a square matrix ($\det(A)$) of dimension $idim$ and order n. A working area ir is returned which is needed by the Dfinv routine.

Author: T. Glebe

1.21

template <class Matrix, unsigned int n, unsigned int idim> bool **Dfinv** (Matrix& rhs, unsigned int* ir)

Dfinv

Dfinv. Function to compute the inverse of a square matrix (A^{-1}) of dimension $idim$ and order n. The routine Dfactir must be called before Dfinv!

Author: T. Glebe

1.22

template <unsigned int idim, unsigned int n = idim> class **Invert**

Invert

Public Members

template <class Matrix> static bool
Dinv (Matrix& rhs)

Invert. Class to specialize calls to Dinv. Dinv computes the inverse of a square matrix if dimension $idim$ and order n. The content of the matrix will be replaced by its inverse. In case the inversion fails, the matrix content is destroyed. Invert specializes Dinv by the matrix order. E.g. if the order of the matrix is two, the routine Invert<2> is called which implements Cramers rule.

Author: T. Glebe

1.23

template <> class Invert **0**

Invert<0>

Public Members

template <class Matrix> inline static bool
Dinv (Matrix& rhs)

Invert<0>. In case of zero order, do nothing.

Author: T. Glebe

1.24

template <> class Invert **1**

Invert<1>

Public Members

template <class Matrix> static bool
Dinv (Matrix& rhs)

Invert<1>. 1×1 (sub-)matrix. $a_{11} \rightarrow 1/a_{11}$

Author: T. Glebe

1.25

template <> class Invert **2**

Invert<2>

Public Members

template <class Matrix> static bool
Dinv (Matrix& rhs)

Invert<2>. 2×2 (sub-)matrix. Use Cramers rule.

Author: T. Glebe

1.26

template <> class Invert **3**

Invert<3>

Public Members

template <class Matrix> static bool
Dinv (Matrix& rhs)

Invert<3>. 3×3 (sub-)matrix. Use pivotisation.

Author: T. Glebe

1.27

template <class Matrix, unsigned int n, unsigned int idim> bool **Dsfact** (Matrix& rhs, typename Matrix::value_type& det)

Dsfact

Dsfact. Compute determinant of a symmetric, positive definite matrix of dimension $idim$ and order n.

Author: T. Glebe

1.28

template <class T, int n, int idim> bool **Dsinv** (T* a)

Dsinv

Dsinv. Compute inverse of a symmetric, positive definite matrix of dimension $idim$ and order n.

Author: T. Glebe

1.29

template <class T> T **erf_0_** (int n, const T& rhs)

*erf_0_*

erf_0_. Routine which does the basic work.

Author: T. Glebe

1.30

template <class T> T **erf** (const T& rhs)

Error function

Error function.

$$\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$$

Author: T. Glebe

1.31

template <class T> T **erfc** (const T& rhs)

Error function

Error function.

$$\mathrm{erfc}(x) = \frac{2}{\sqrt{\pi}} \int_x^\infty e^{-t^2} dt$$

Author: T. Glebe

1.32

template <class T> T **Prob** (const T& rhs, int n)

Upper Tail Probability of Chi-Squared Distribution

Upper Tail Probability of Chi-Squared Distribution.

$$Q(X|N) = \frac{1}{\sqrt{2^N}\Gamma(\frac{1}{2}N)} \int_X^\infty e^{-\frac{1}{2}t} t^{\frac{1}{2}N-1} dt$$

Author: T. Glebe

1.33

static bool **errfunc** (const char* expr, const char* function, const unsigned int line)

errfunc

errfunc. Function which prints an error message and then exits the program.

Author: T. Glebe

1.34

#define **Sassert** (expr)

Sassert

Sassert. An assert macro which is invoced only once (in contrast to standard assert(), which is repeatedly called). Sassert is more performant in case it is placed in a routine which is called more than once. Otherwise assert() is more performant.

Author: T. Glebe

1.35

template <class T, class P> bool **Rminfc** (T (*f)(P), P a, P b, double eps, double delta, P& x, P& y)

Rminfc

Rminfc. Function which finds a single, local minimum of a function with one variable in a given interval. The "golden section search" is

applied. The method uses a fixed number n of function evaluations, where $n = [2.08 \cdot \ln(|a-b|/\epsilon) + 1/2] + 1$.

Parameters:

`f` — one-dimensional function
`a,b` — end-points of search interval
`eps` — accuracy parameter ϵ
`delta` — tolerance interval δ near a and b. Suggested value: $\delta = 10\epsilon$
`x` — computed approximation to the abscissa of a minimum of the function f
`y` — value of $f(x)$

1.36

template <class C, class T, class P> bool **RminfcM** (const C& part, T (C::*f)(P) const, P a, P b, double eps, double delta, P& x, P& y)

RminfcM

RminfcM. Rminfc version for const class member functions.

Function which finds a single, local minimum of a function with one variable in a given interval. The "golden section search" is applied. The method uses a fixed number n of function evaluations, where $n = [2.08 \cdot \ln(|a-b|/\epsilon) + 1/2] + 1$.

Parameters:

`f` — one-dimensional function
`a,b` — end-points of search interval
`eps` — accuracy parameter ϵ
`delta` — tolerance interval δ near a and b. Suggested value: $\delta = 10\epsilon$
`x` — computed approximation to the abscissa of a minimum of the function f
`y` — value of $f(x)$

2 SVertex

A high-speed C++ vertex fit class (formerly Vt++).

Names

2.1 template <unsigned int NTR> class
SVertex : public VertexIf, public TrackIf
Fixed size Vertex class 28

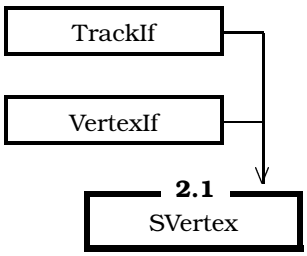
2.2 template <unsigned int NTR> class
SKalman : public TrackIf
Fixed size Kalman filter class 35

Author: T. Glebe, MPI fuer Kernphysik Heidelberg

2.1 template <unsigned int NTR> class **SVertex** : public VertexIf, public TrackIf

Fixed size Vertex class

Inheritance



Public Members

— Constructors —

SVertex ()

SVertex (const SVertex<NTR>& rhs)

SVertex (const TrackIf& t)
create Vertex object & set mother track by t

SVertex (const TrackIf& t1, const TrackIf& t2)

SVertex (const TrackIf& t1, const TrackIf& t2, const TrackIf& t3)

SVertex (const TrackIf& t1, const TrackIf& t2, const TrackIf& t3, const TrackIf& t4)

SVertex (const SVertex<NTR-1>& vtx, const TrackIf& t)
add a track

SVertex <NTR> &
operator= (const SVertex<NTR>& rhs)

— static variables —

static const unsigned int
size

— VertexIf Access methods —

float	**vx** () const	*vertex x position v_x*
float	**vy** () const	*vertex y position v_y*
float	**vz** () const	*vertex z position v_z*
float	**chi2** () const	*vertex χ^2*
unsigned short int	**ndf** () const	*degrees of freedom of vertex fit*
float	**prob** () const	*upper tail χ^2 probability*
unsigned short int	**ntracks** () const	*no of tracks in vertex*

const TrackIf*
track (unsigned int i) const
read only track access

const TrackIf*&

track (unsigned int i)
read/write track access

SVector <double, 3>
vpos () const *vertex position* $\vec{v} = (v_x,\ v_y,\ v_z)$

const SMatrix <double, 3> &
VCOV () const *vertex cov. matrix*

float **vtx_cov_x** () const
σ_x^2 *of vertex*

float **vtx_cov_y** () const
σ_y^2 *of vertex*

float **vtx_cov_z** () const
σ_z^2 *of vertex*

— SVertex members —

const SVector <double, 3> &
vposR () const *vertex position* $\vec{v} = (v_x,\ v_y,\ v_z)$ *(fast readonly access)*

SVector <double, 3> &
vposR () *vertex position* $\vec{v} = (v_x,\ v_y,\ v_z)$ *(fast read/write access)*

void **set_vpos** (const SVector<double, 3>& pos)
set vertex position manually

void **set_track** (unsigned int i, const TrackIf& t)
set track list

const SKalman <NTR> &
kalman (unsigned int i) const
read only access to Kalman objects

SKalman <NTR> &
kalman (unsigned int i)
read/write access to Kalman objects

const SMatrix <double, 3> &
VCINV () const *inverse vertex cov. matrix*

const SVector <double, 6> &
mother () const *mother track parameters* $\vec{m} = (x,\ y,\ z,\ t_x,\ t_y,\ p)$

const SMatrix <double, 3*NTR+3> &

covn () const *for internal use only*

— Vertex computations —

SVector <double, 3>
findVertex2D () const
return vertex computed with 2D analytical method

bool **calcVertex2D** () *compute vertex with a 2D analytical method*

bool **findVertex3D** (SVector<double, 3>& pos) const
return vertex computed with 3D analytical method

bool **findVertexVt** () *Vt based Kalman filter vertex fit*

bool **findVertexNe** () *Vt based Kalman filter vertex fit, without first estimation*

SVector <double, 2>
rmsDistAngle () const
return rms distance and rms opening angle of tracks in vertex

SVector <double, 3>
EstimateVertex () const
compute vertex with error weighted 2D analytical method

double **mass** (const SVector<double, NTR>& rm) const
compute invariant mass using refitted track momenta

double **massError** (const SVector<double, NTR>& rm) const
compute invariant mass error caused by momentum error

double **mass_tr** (const SVector<double, NTR>& rm) const
compute invariant mass using measured track momenta

2.1.1 **— TrackIf Access methods —** 34

float **x** () const x *of reconstructed track*

float	**y** () const	*y of reconstructed track*
float	**x** (float z) const	*linear extrapolation of x to z*
float	**y** (float z) const	*linear extrapolation of y to z*
float	**z** () const	*z of reconstructed track*
float	**tx** () const	*mother track rack slope t_x*
float	**ty** () const	*mother track slope t_y*
float	**p** () const	*mother track momentum p*
float	**pt** () const	*transverse mother track momentum p_t*
float	**pz** () const	*mother track momentum along z: $p/\sqrt{t_x^2+t_y^2+1}$*
float	**phi** () const	*azimuthal angle ϕ [deg]*
float	**theta** () const	*polar angle $\theta = \cos^{-1}(e_z)$ [deg]*
float	**eta** () const	*rapidity $\eta = -\log\tan(\theta/2.)$*
int	**charge** () const	*track charge (=sum of track charges in vertex)*
float	**energy** (double mass = 0.) const	$E = \sqrt{m^2+p^2}$
float	**xf** (double mass = 0.) const	$x_f = (p_z - E(m) \cdot \sqrt{1-\frac{2m_p}{920GeV/c+m_p}})/m_p$, m_p = *Proton mass,* m = *Particle mass*
float	**rap** (double mass = 0.) const	*Rapidity* $y = \frac{1}{2}\ln(\frac{E+p_z}{E-p_z})$
float	**cov_x** (double dz=0.) const	*get* $\sigma_x^2|_{z+dz}$
float	**cov_y** (double dz=0.) const	*get* $\sigma_y^2|_{z+dz}$
float	**cov_tx** () const	*get* $\sigma_{t_x}^2$
float	**cov_ty** () const	*get* $\sigma_{t_y}^2$
float	**cov_p** () const	*get* σ_p^2

bool	**isValid** () const	*Kalman fit: reconstructed track and covariance matrix are computed and propagated to $z = 0$? else: is reconstructed track computed?*
void	**valid** ()	*mark mother track as valid*
void	**invalid** ()	*mark mother track as invalid*
SVector <double, 3>	**xvec** () const	*position $\vec{x} = (x,\ y,\ z)$ of mother track*
SVector <double, 3>	**tvec** () const	*slope $\vec{t} = (t_x,\ t_y,\ 1)$ of mother track*
SVector <double, 3>	**evec** () const	*$\vec{e} = (e_x,\ e_y,\ ez)$ unit vector along $\vec{p}$ of mother track*
SVector <double, 3>	**pvec** () const	*mother track momentum vector $\vec{p} = (p_x,\ p_y,\ p_z)$*
const SMatrix <double, 5> &	**COV** () const	*covariance matrix of mother track*
const SMatrix <double, 5> &	**CINV** () const	*inverse cov. matrix of mother track*
void	**collect** (vector<TrackIf*>& c) const	*collect pointers*
bool	**propagate** (const double z)	*propagate reconsructed track to z*
std::ostream&	**print** (std::ostream&) const	*used by operator<<()*
	— Operators —	
bool	**operator==** (const TrackIf& rhs) const	*compare TrackIf pointers*
	— SVertex methods —	
bool	**isMotherTr** () const	

		is mother track calculated?
bool	**isMotherCov** () const	*is mother cov. matrix calculated?*
bool	**isKalmanFit** () const	*has Kalman fit succeeded?*
bool	**filter** ()	*do a filter step*
bool	**smooth** ()	*smooth vertex parameters*
bool	**smoothC** ()	*needed for bigcov()*
inline double	**bk13** () const	
bool	**calc_mother** ()	*calculate mother track + cov. matrix*
bool	**calc_mother_tr** ()	*calculate mother track using kalman info*
bool	**calc_mother_trtr** ()	*calculate mother track using track info*
bool	**calc_mother_cov** ()	*calculate covariance matrix of mother track*
bool	**bigcov** ()	*construct* $(3 \cdot n + 3) \times (3 \cdot n + 3)$ *cov. matrix*

Fixed size Vertex class.

Author: T. Glebe

2.1.1 — TrackIf Access methods —

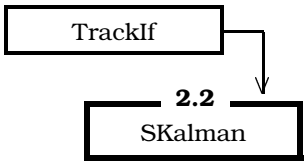
The following functions apply only to the mother track and give only useful results in case you reconstructed the mother track (see section of expert methods).

2.2

template <unsigned int NTR> class **SKalman** : public TrackIf

Fixed size Kalman filter class

Inheritance



Public Members

— Constructors —

SKalman ()

SKalman (const TrackIf& t,
const SVertex<NTR>& v)

— TrackIf methods —

float	**x** () const	*refitted Track x position (= vertex x position)*
float	**y** () const	*refitted Track y position (= vertex y position)*
float	**x** (float z) const	*refitted Track x position at z*
float	**y** (float z) const	*refitted Track y position at z*
float	**z** () const	*refitted Track z position (= vertex z position)*
float	**tx** () const	*refitted track slope t_x*
float	**ty** () const	*refitted track slope t_y*
float	**p** () const	*refitted momentum*
float	**pt** () const	*refitted transverse Track momentum p_t*

float	**pz** () const	*momentum along z:* $p/\sqrt{t_x^2+t_y^2+1}$
float	**chi2** () const	*Kalman* χ^2*. Use only if you know what it is!*
float	**phi** () const	*refitted azimuthal angle* ϕ *[deg]*
float	**theta** () const	*refitted polar angle* $\theta = \cos^{-1}(e_z)$ *[deg]*
float	**eta** () const	*refitted rapidity* $\eta = -\log\tan(\theta/2.)$
int	**charge** () const	*particle charge: -1 for neg. +1 for pos. & neutrals*
float	**energy** (double mass = 0.) const	$E = \sqrt{m^2+p^2}$
float	**xf** (double mass = 0.) const	$x_f = (p_z - E(m) \cdot \sqrt{1-\frac{2m_p}{920GeV/c+m_p}})/m_p$, m_p *= Proton mass,* m *= Particle mass*
float	**rap** (double mass = 0.) const	*Rapidity* $y = \frac{1}{2}\ln(\frac{E+p_z}{E-p_z})$
SVector <double, 3>	**xvec** () const	*vertex position*
SVector <double, 3>	**tvec** () const	$\vec{v} = (t_x,\ t_y,\ 1.)$ *refitted slope vector*
SVector <double, 3>	**evec** () const	$\vec{v} = (e_x,\ e_y,\ e_z)$ *unit vector along refitted track*
SVector <double, 3>	**pvec** () const	$\vec{v} = (p_x,\ p_y,\ p_z)$ *refitted mom. vector*
void	**collect** (vector<TrackIf*>& c) const	*collect pointers*
	— Dummy TrackIf functions —	
bool	**isValid** () const	*returns always true*
void	**valid** ()	*does nothing*

void **invalid** () *does nothing*

const SMatrix <double, 5> &
COV () const *returns a 0 matrix*

const SMatrix <double, 5> &
CINV () const *returns a 0 matrix*

bool **propagate** (const double z)
dummy function: do nothing

unsigned short int
ndf () const *returns always 0*

float **cov_x** (double dz=0.) const
returns 0

float **cov_y** (double dz=0.) const
returns 0

float **cov_tx** () const *returns 0*

float **cov_ty** () const *returns 0*

float **cov_p** () const *returns 0*

— Operators —

bool **operator==** (const TrackIf& rhs) const
compare TrackIf pointers

— Access methods —

const SMatrix <double, 3> &
KCOV () const

const SMatrix <double, 3> &
KCINV () const

const SVector <double, 3> &
xv () const

const SMatrix <double, 3> &
F () const

const SMatrix <double, 3> &
ES () const

const SMatrix <double, 3> &
DS () const

— Expert methods —

bool **filter** (const unsigned int I)
filter step

bool **smooth** () *smoother step*

bool **smoothC** () *cov. matrices of smoothed parameters*

std::ostream&
print (std::ostream&) const
used by operator<<()

Fixed size Kalman filter class.

Author: T. Glebe

3 SDistance

Distance functions for Track and Vertex objects.

Names

3.1 inline double
Sdistance (const SVector<double, 3>& x1,
const SVector<double, 3>& x2)
Spatial distance between two space points 40

3.2 inline double
Sdistance (const VertexIf& v1,
const VertexIf& v2)
Spatial distance between two VertexIf objects 41

3.3 inline double
SGNVVdistance (const VertexIf& v1,
const VertexIf& v2)
Signed spatial distance between two VertexIf objects ... 41

3.4 inline double
Sdistance (const VertexIf& v,
const SVector<double, 3>& x)
Spatial distance between Vertex and space point 42

3.5 inline double
TVdistance (const TrackIf& t,
const VertexIf& v)
Clostest spatial distance between Track and Vertex object 42

3.6 inline double
Tdistance (const TrackIf& t1,
const TrackIf& t2)
Clostest spatial distance between two Track objects 42

3.7 inline double

Sdistance (const TrackIf& t, const Wire& w)
Closest spatial distance between Track and Wire 43

3.8 inline double
SGNdistance (const TrackIf& t,
const VertexIf& v)
Signed closest distance between Track and Vertex object 43

3.9 inline double
Chi2distance (const TrackIf& t1,
const TrackIf& t2)
χ^2 *distance between two tracks* 44

3.10 template <unsigned int NTR> inline double
Chi2distance (const SVertex<NTR>& v,
const SVector<double, 3>& x)
χ^2 *distance between SVertex and space point* 44

3.11 template <unsigned int NTR, unsigned int NTR2> inline double
Chi2distance (const SVertex<NTR>& v1,
const SVertex<NTR2>& v2)
χ^2 *distance between two SVertex objects* 44

Author: T. Glebe, MPI fuer Kernphysik Heidelberg

3.1

inline double **Sdistance** (const SVector<double, 3>& x1, const SVector<double, 3>& x2)

Spatial distance between two space points

Spatial distance between two space points.

$$d = |\vec{x}_1 - \vec{x}_2|$$

3.2

inline double **Sdistance** (const VertexIf& v1, const VertexIf& v2)

Spatial distance between two VertexIf objects

Spatial distance between two VertexIf objects.

$$d = |\vec{v}_1 - \vec{v}_2|$$

3.3

inline double **SGNVVdistance** (const VertexIf& v1, const VertexIf& v2)

Signed spatial distance between two VertexIf objects

Signed spatial distance between two VertexIf objects.

$$d = |\vec{v}_1 - \vec{v}_2| \times \mathtt{sgn}(v_{z,1} - v_{z,2})$$

3.4

inline double **Sdistance** (const VertexIf& v, const SVector<double, 3>& x)

Spatial distance between Vertex and space point

Spatial distance between Vertex and space point.

$$d = |\vec{x}_v - \vec{x}|$$

3.5

inline double **TVdistance** (const TrackIf& t, const VertexIf& v)

Clostest spatial distance between Track and Vertex object

Clostest spatial distance between Track and Vertex object.

$$d = \frac{|(\vec{x}_t - \vec{x}_v) \times \vec{t}|}{|\vec{t}|}$$

$g : \vec{x}_t + m \cdot \vec{t}$ track definition
$\vec{x}_v$: vertex position

3.6

inline double **Tdistance** (const TrackIf& t1, const TrackIf& t2)

Clostest spatial distance between two Track objects

Clostest spatial distance between two Track objects.

$$d\vec{x} = \vec{x}_2 - \vec{x}_1$$
$$f_1 = d\vec{x} \cdot \frac{\vec{t}_1}{|\vec{t}_1|}$$
$$f_2 = d\vec{x} \cdot \frac{\vec{t}_2}{|\vec{t}_2|}$$
$$d = \left| d\vec{x} + f_2 \cdot \frac{\vec{t}_2}{|\vec{t}_2|} - f_1 \cdot \frac{\vec{t}_1}{|\vec{t}_1|} \right|$$

$g : \vec{x}_1 + m \cdot \vec{t}_1$ track definition 1st track
$g : \vec{x}_2 + m' \cdot \vec{t}_2$ track definition 2nd track

3.7

inline double **Sdistance** (const TrackIf& t, const Wire& w)

Closest spatial distance between Track and Wire

Closest spatial distance between Track and Wire.

$$d = \frac{(\vec{t}_w \times \vec{t}_t) \cdot (\vec{x}_t - \vec{x}_w)}{|\vec{t}_w \times \vec{t}_t|^2}$$

$g : \vec{x}_t + m \cdot \vec{t}_t$ track definition
$w : \vec{x}_w + m' \cdot \vec{t}_w$ wire definition

3.8

inline double **SGNdistance** (const TrackIf& t, const VertexIf& v)

Signed closest distance between Track and Vertex object

Signed closest distance between Track and Vertex object. The sign is determined by the z component and tells whether the point of closest approach is upstream or downstream of the vertex position.

$$\rho = \frac{\vec{t} \cdot (\vec{x}_t - \vec{x}_v)}{|\vec{t}|}$$

$$d\vec{x} = \vec{x}_t - \rho \cdot \vec{t} - \vec{x}_v$$

$$d = \mathrm{sgn}(d\vec{x}_z) \cdot |d\vec{x}|$$

$g : \vec{x}_t + m \cdot \vec{t}$ track definition
$\vec{x}_v$: vertex position
$\vec{x}_t - \rho \cdot \vec{t}$: point of track closest to vertex

3.9

inline double **Chi2distance** (const TrackIf& t1, const TrackIf& t2)

χ^2 distance between two tracks

χ^2 distance between two tracks. Determined by Kalman filter vertex fit.

3.10

template <unsigned int NTR> inline double **Chi2distance** (const SVertex<NTR>& v, const SVector<double, 3>& x)

χ^2 distance between SVertex and space point

χ^2 distance between SVertex and space point.
Assumption: SVertex has been fitted with findVertexVt().

3.11

template <unsigned int NTR, unsigned int NTR2> inline double **Chi2distance** (const SVertex<NTR>& v1, const SVertex<NTR2>& v2)

χ^2 distance between two SVertex objects

χ^2 distance between two SVertex objects.
Assumption: Both SVertex objects have been fitted with findVertexVt().

Class Graph

1.1 SVector 6

1.2 SMatrix 9

1.3 Expr 14

1.4 BinaryOp 15

1.5 UnaryOp 15

1.6 Constant 16

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1.22 Invert 21

1.23 0 22

1.24 1 22

1.25 2 23

1.26 3 23

2.1 SVertex 28

2.2 SKalman 35