SCETLIB.

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Main developers:
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Eventually, we might also want others (theorists and experimentalists alike) to be able to use our results ...

- Nontrivial effort is required to go from a working code we can use ourselves to a code our collaborators can use
- Nontrivial effort is required to go from a code our collaborators can use to a code everyone can use

Design and Philosophy.

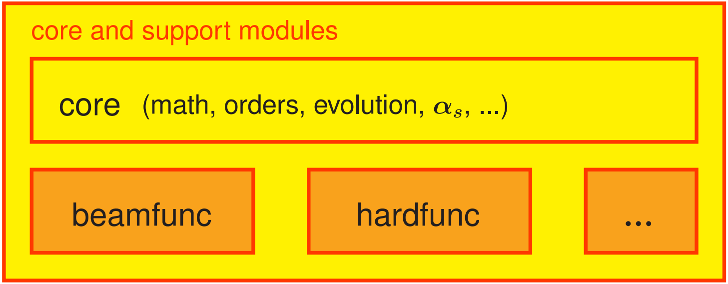
In contrast to existing resummation codes, SCETLIB is meant and designed as a *library* (mostly written in C++)

- Not only a black box to (re)produce an existing result but also a toolbox to build new results
  - Barrier of adoption for new result is significantly lowered when available in an already familiar format/framework

Main design goals

- User-friendly
  - Intuitive (physics-driven) and powerful library interface (API) for toolbox users
  - Ease of use for end (blackbox) users
  - Safety against unintentional or accidental misuse for either
- Modular design
  - Reuse and rely on existing, validated, well-tested components
  - Infrastructure to assemble building blocks
  - Allow for flexibility, extendability, scaleability
- Stability and speed

Overview of SCETLIB.



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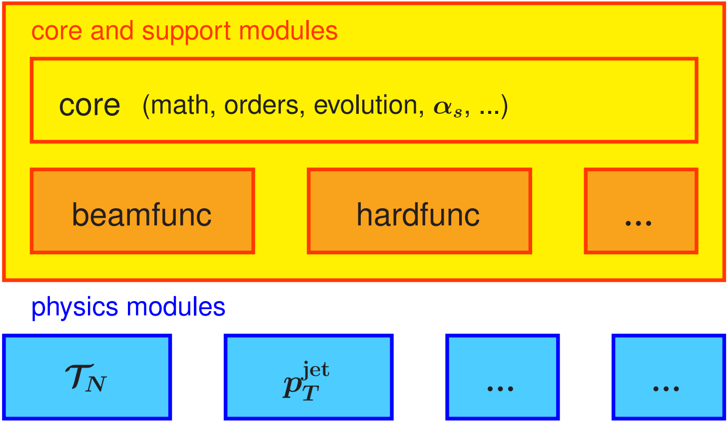

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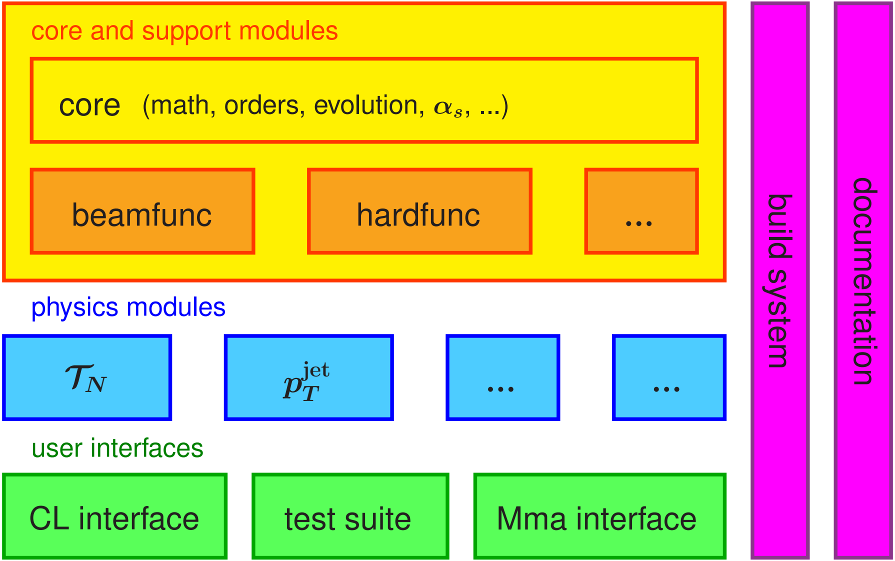


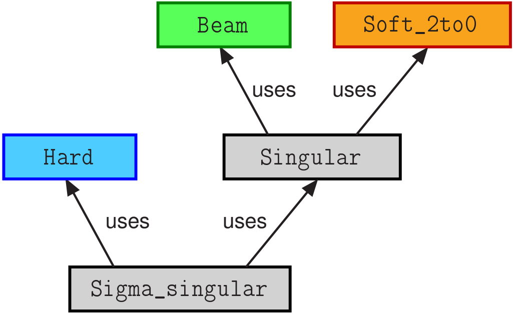
Factorization as Design Principle.

“Factorization” is one of the core design principles in C++ (and in general)

- Break up problem into smaller pieces
  - Each piece does one thing and does it well
  - Complexity is achieved through their interactions
- For us, it means that the logical (i.e. physics) factorization is directly reflected in the code
- Example:

  Structure of $\mathcal{T}_N$ module

$$\sigma(Q, Y, \tau) = H(Q) \times \left[B(Qe^{Y}) \otimes B(Qe^{-Y}) \otimes S\right](\tau)$$



Example: Interface of TauN::Singular.

```
class Singular
{
   public:
      using Phi = Phi_label_2to0;
      using Color = Soft_2to0::Color;

      // constructor
      Singular(Color color, Resum_order order, RunningCoupling<>& alphas,

      // Returns distribution-valued perturbative series.
      JointDistribution operator()(Phi phi, Scales scales) const;

      // Evaluate the spectrum at Tau.
      auto spectrum(Phi phi, double Tau, Scales scales) const;

      // Evaluate the cumulant up to TauCut.
      auto cumulant(Phi phi, double TauCut, Scales scales) const;

   private:
      Resum_order _order;                // resummation order
      RunningCoupling<>& _alphas;        // running coupling
      Beam _beam;                        // beam functions
      Soft_2to0 _soft;                   // soft function
};
```

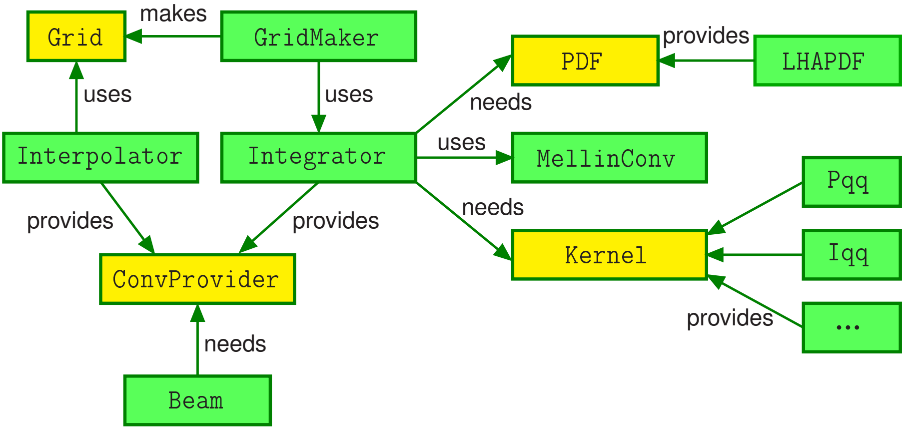
Example: Implementation of TauN::Singular.

```
// constructor
Singular::Singular(Color color, Resum_order order,
                   RunningCoupling<>& alphas, ...)
   : _order(order), _alphas(alphas),
     _beam(color == qqbar ? Beam::quark : Beam::gluon, order, alphas, ...)
     _soft(color, order, alphas)
{}

// _beam and _soft return distribution-valued perturbative series
// including RG evolution.
// Their multiplication operator* evaluates their convolution.
JointDistribution Singular::operator()(Phi phi, Scales scales) const
{
   return _beam(phi.channel.fa, phi.wa, scales.muBa, scales.mu)
          * _beam(phi.channel.fb, phi.wb, scales.muBb, scales.mu)
          * _soft(scales.muS, scales.mu);
}

// Evaluate the spectrum at Tau.
auto spectrum(Phi phi, double Tau, Scales scales) const
{
   return (*this)(phi, scales).spectrum(Tau);
}
```

Beam Function Module.

Facilities for beam function coefficients and convolutions $\int \frac{dz}{z}\, I_{ij}(z)\, f_j\!\left(\frac{x}{z}\right)$

- Flexible: Different ways to provide convolutions
  (via fast grid interpolation and/or on-the-fly integration)
- Extendable: Easy to add new kernels (or other provider strategies)



Mathematica Interface.

Mathematica is convenient for plotting etc., but interfacing it to external C++ code can be excruciating (if you ever tried, you know what I mean ...)

SCETLIB's Mathematica interface provides access to its functionality from Mathematica in a few easy steps

- Write a simple class that exposes the desired functionality

```
//MMA_EXPORT_CLASS//
class DrellYan
{
   public:
      //MMA_EXPORT//
      DrellYan(...) { ... } // setup the _sigma

      //MMA_EXPORT//
      double spectrumResummedQY(double Q, double Y, double Tau,
                                complex muH, double muB, double muS)
      {
         return _sigma.spectrum(Phi{Q, Y}, Tau, muH, Scales{muB, muS, Q});
      }

   private:
      Sigma_singular<hardfunc::DrellYan> _sigma;
}
```

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- Write a simple class that exposes the desired functionality
- Run the MmaInterface, which automatically
  - Parses the class definitions
  - Generates source code for a Wolfram LibraryLink library and builds it
  - Generate a corresponding Mma package to use the LibraryLink library
  - Can also export multiple classes in one package
- In Mathematica
  - Load the package
  - Create objects of the exported class(es), where each object can have its own settings and multiple objects can coexist
  - Call their exported member functions
  - Errors (exceptions) in the C++ code are caught and passed through as Mma warnings

→ Live Demo ...

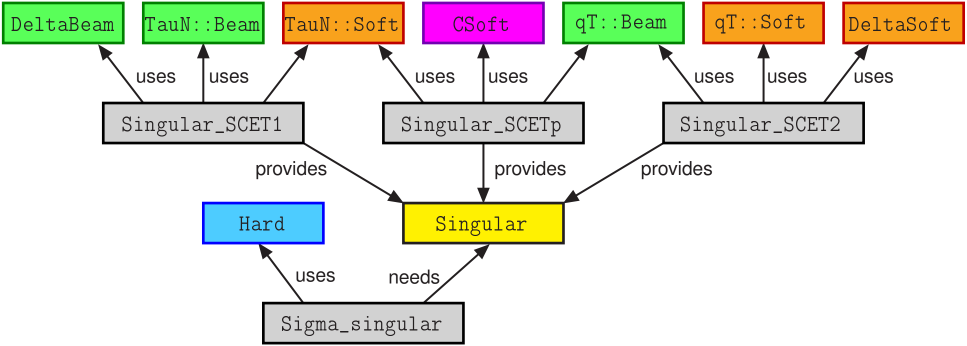
Nontrivial Example: Double-differential $\mathcal{T}_0 - q_T$

[→ see Gillian's talk for the physics details]

$$\sigma_{\mathrm{I}}(\mathcal{T}_0, q_T) = H \times B(\mathcal{T}_0, q_T)^2 \otimes S(\mathcal{T}_0)$$
$$= B(\mathcal{T}_0) + \Delta B(\mathcal{T}_0, q_T)$$

$$\sigma_{+}(\mathcal{T}_0, q_T) = H \times B(q_T)^2 \otimes \mathcal{S}(\mathcal{T}_0, q_T)^2 \otimes S(\mathcal{T}_0)$$

$$\sigma_{\mathrm{II}}(\mathcal{T}_0, q_T) = H \times B(q_T)^2 \otimes S(\mathcal{T}_0, q_T)$$
$$= S(q_T) + \Delta S(\mathcal{T}_0, q_T)$$



Summary and Outlook.

SCETLIB strives to be an easy-to-use, powerful, multi-purpose library

- Significantly reduce effort to numerically implement new calculations
- Rely on tested and validated implementations of existing ingredients
- Make results available to the experimental and theoretical community

⇒ Get more easily

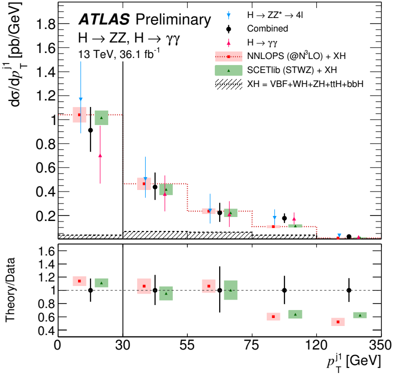
from here

$$
\begin{aligned}
\sigma_0(p_T^{\rm cut}) &= \sigma_B H_{gg}(m_t, m_H, \mu_H) \int \mathrm{d}Y\, B_g(m_H, p_T^{\rm cut}, R, x_a, \mu_B, \nu_B) \\
&\quad \times B_g(m_H, p_T^{\rm cut}, R, x_b, \mu_B, \nu_B)\, S_{gg}(p_T^{\rm cut}, R, \mu_S, \nu_S) \\
&\quad \times U_0(p_T^{\rm cut}, R; \mu_H, \mu_B, \mu_S, \nu_B, \nu_S) \\
&\quad + \sigma_0^{R\mathrm{sub}}(p_T^{\rm cut}, R) + \sigma_0^{\rm ns}(p_T^{\rm cut}, R, \mu_{\rm ns})\,, \qquad (56)
\end{aligned}
$$

where the combined renormalization group evolution factor U_0 is given by

$$
\begin{aligned}
U_0(p_T^{\rm cut}, R; \mu_H, \mu_B, \mu_S, \nu_B, \nu_S) &= \left| \exp\left[\int_{\mu_H}^{\mu_B} \frac{\mathrm{d}\mu'}{\mu'}\, \gamma_H^g(m_H, \mu') \right] \right|^2 \\
&\quad \times \exp\left[\int_{\mu_S}^{\mu_B} \frac{\mathrm{d}\mu'}{\mu'}\, \gamma_S^g(\mu', \nu_S) \right] \\
&\quad \times \exp\left[\ln\frac{\nu_B}{\nu_S}\, \gamma_\nu^g(p_T^{\rm cut}, R, \mu_B) \right]. \qquad (57)
\end{aligned}
$$

to here



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Outlook

- Current v0.4: Not-yet public
  - Could only show you some of the features
- Next v0.5: Will be public
  - If interested, watch this space: **http://scetlib.desy.de**
  - or tell me to add you to the **scetlib-announce@desy.de** email list